21st Century Skills Mastery Amongst Science Foundation Programme Students

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Abstract— **The rapid growing of knowledge economy that relies on the advancement of ICT has changed the trend of employment and social life. Employers in this century are looking for competitive, innovative and global employees. As a consequence, students should be prepared to acquire 21st-century skills so that they can be successful in the employment and social life. Before that, this study has examined the mastery level of the 21st-century skills amongst science foundation programme students. This study has also investigated the relationships between former school location and gender on the mastery levels of the 21st-century skills. A total of 240 students from two foundation colleges participated in this quantitative study. The findings indicated that the mastery level of the 21st-century skills was high. All subdomains of the 21st-century skills were at a high mastery level. However, economy literacy as one of digital era literacy subdomains showed a moderate level. Meanwhile, creativity as one of the inventive thinking subdomains also showed a moderate level, and interactive communication as one of effective communication subdomains also showed a moderate level. Findings also revealed that there were no significant differences between former school location and gender on the mastery levels of the 21st-century skills amongst science foundation programme students.**

Keywords— **21st century skills; digital age literacy; inventive thinking; effective communication; high productivity.**

I. INTRODUCTION

21st-century skills are much demanded in the advancement of our current world that greatly relies on Information and Communication Technology (ICT). The mastery of the 21st-century skills becomes pivotal for the individuals to be competitive in the workplace and ICT is the focus of their development [1]. The growing of the global knowledge society and rigorous integration of ICT require a young generation to possess digital skills essential for employment and involvement in society [2]. Instead, the contemporary labor markets value and reward the employees who acquire advanced technical abilities and also capable of applying higher-order cognitive skills within an ICT context [3]. Therefore, one of the challenges in the education sector nowadays is the enhancement of the 21st-century skills among the students [4]. As derived by North Central Regional Educational Laboratory (NCREL) and Metiri Group, the 21st-century skills comprise of digital era literacy, inventive thinking, effective communication and high productivity [5].

Digital era literacy is defined as the ability to use digital technologies to read, analyze, manage and evaluate available information to produce new information that contributes to the knowledge. Inventive thinking means the ability to manage complexity, curious, creativity and risk-taking, and higher-order thinking and sound reasoning. Effective communication is referred to as the ability in teaming, collaborating and interpersonal skills, accountable in personal and social responsibility, and using technology in interactive communication. High productivity describes an individual's ability to prioritize planning with the use of real-world technology and produce quality work that able to solve problems [5].

As Malaysia is moving towards a developed nation shortly, it needs a well-trained workforce in science and technology that are competitive, innovative and global for the demand of work in the 21st century. However, based on the Programme for International Student Assessment (PISA) report, the mastery of the 21st-century skills among secondary science students was not promising [6]. Meanwhile, Malaysia postgraduate students showed a low

level of critical and creative thinking and not proficient in effective communication [7].

Some researchers have investigated the mastery of the 21st-century skills in these past few years. For instance, a study was carried out that the mastery level of the 21st-century skills among Form Four Physics students (aged 16 years) in Selangor was moderate [8]. There were no significant differences in the mastery level of the 21st-century skills-based on former school location and gender. In another study, it is investigated the mastery level of Form Four Biology students (aged 16 years) in Selangor was also moderate [9]. However, there was a significant difference in the mastery level of the 21st-century skills based on gender.

Another study investigated the mastery of 21st-century skills among Alternative Learning System (ALS) in Northern Philippines [4]. This ALS programme was set up to promote continuing education to the marginalized groups such as children, drop out of school youth, women, special needs people and native community who did not complete their basic education due to poverty and support problems. The findings revealed that their mastery level of the 21st century was low. Regarding gender difference, there were no significant differences in thinking skills, collaboration skills, communication skills, self-direction, global and local connection and ICT skills. However, creativity and innovation skills demonstrated significant differences between male and female learners. The mastery level of creativity and innovation was higher for male learners compared to female learners.

Since the acquisition of the 21st-century skills is vital for the young generation to be competitive in the workplace and participative in life, this paper seeks to investigate the mastery level of these abovementioned skills among science foundation programme students.

This paper's objective is to report on the following:
- The mastery level of the 21st-century skills amongst science foundation programme students.
- The mastery level of digital era literacy amongst science foundation programme students.
- The mastery level of inventive thinking amongst science foundation programme students.
- The mastery level of effective communication skils amongst science foundation programme students.
- The effects of former school location and gender on the 21st-century skills.
- The effects of former school location and gender on digital age literacy.
- The effects of former school location and gender on inventive thinking.
- The effects of former school location and gender on effective communication skills
- The effects of former school location and gender on high productivity.

II. MATERIAL AND METHOD

A. Research Instrument

The 21st-century skills instrument developed by [10], [11] was administered in this survey method study. The four main domains of the 21st-century skills are displayed in Table 1.

TABLE I
THE CONTENT OF THE 21ST-CENTURY SKILLS INSTRUMENT

Domain	No.of item	Item no.	Cronbach Value
Digital era literacy	24	C1-C24	0.88
Inventive thinking	42	D1-D42	0.92
Effective communication	15	E1-E15	0.74
High productivity	18	F1-F18	0.89

A Likert scale ranged from 1 to 5 (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree) was applied in this study. The mastery of the 21st-century skills was categorized into three levels (high, moderate, low) based on the mean as displayed in Table 2.

TABLE II
LEVEL OF MASTERY

Level	Mean
High	3.67 – 5.00
Moderate	2.34 – 3.66
Low	1.00 – 2.33

B. Data analysis procedures

The students' responses from the questionnaires are analyzed using Statistical Package for Social Sciences (SPSS). In descriptive statistics study, mean and standard deviation (sd) were calculated to measure the mastery level of the 21st-century skills. In inferential statistic study, analysis of two-way ANOVA was carried out to find the relationships between former school location and gender on the 21st-century skills. In this study, the researcher defines the former school location as the urban or rural area where the schools were located before these students entering the science foundation programme.

III. RESULTS AND DISCUSSION

A. Profile of Respondent

A total of 240 respondents (97 males and 143 females) involved in this study where they are asked to fill out the questionnaires. They have just enrolled as Year One students (aged 18 years) at two foundation colleges fully funded by Majlis Amanah Rakyat (MARA), a Malaysian government agency. They have been selected to attend this science foundation programme based on their excellence results in the national examination for the secondary education. The profile of respondent is illustrated in Fig. 1.
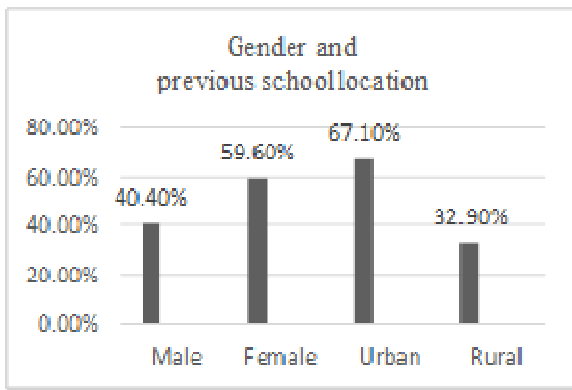
Fig. 1 Profile of respondent

B. Mastery Level of the 21st Century Skills

The overall mastery level of the 21st-century skills was high (mean = 4.03, sd = 0.32) as reported in Table 3.

TABLE III
MEAN AND SD OF THE 21ST-CENTURY SKILLS

Domain	Mean	sd	Level
1.Digital era literacy	4.03	0.38	High
2.Inventive thinking	3.98	0.39	High
3.Effective communication	3.96	0.47	High
4.High productivity	3.94	0.35	High
21st century skills	4.03	0.32	High

All domains of the 21st-century skills indicated a high mastery level. Digital age literacy revealed the highest mean (mean = 4.03, sd = 0.38), while high productivity revealed the lowest mean (mean = 3.57, sd = 1.18). As compared to findings in [8], [9] that showed medium, the mastery of the 21st-century skills among science foundation programme students was higher. This may occur due to the age factor that the students are more matured when they have completed their secondary education and further their studies at the college level.

C. Mastery Level of Digital Era Literacy

The mastery of digital era literacy was at a high level (mean = 4.09, sd = 0.38). The subdomains and their means of digital era literacy are listed in Table 4.

TABLE IV
MEAN AND SD OF DIGITAL AGE LITERACY

Subdomain	Mean	sd	Level
Basic literacy	3.86	0.60	High
Science literacy	4.01	0.48	High
Environmental literacy	4.38	0.50	High
Economic literacy	3.57	1.18	Moderate
ICT literacy	4.17	0.52	High
Global literacy	3.95	0.69	High
Digital era literacy	4.03	0.38	High

Table 5 indicates the overall digital era literacy level was high (mean score = 4.03, sd = 0.38). This means digital era literacy mastery among science programme students was

good. This high mastery level of digital age literacy can be supported by the study carried out by [12] that Malaysia youths use the internet as an essential source of information. They are the Net generation who can easily access the internet to find information. Furthermore, the integration of ICT in the classroom has been emphasized and implemented in Malaysian education system at all level from primary to higher education since a decade ago [13].

All subdomains demonstrated high mastery level except for economic literacy that demonstrated moderate. Economic literacy is students' knowledge and their understanding regarding basics economic theories and their application in daily lives. This finding is in line with the study carried out by [14] that revealed low economic literacy among Form Six students (aged 19-20 years) in the state of Johore. This finding also affirms the study conducted by [15] that measured economics literacy among undergraduates students (aged 22 years) at the International Islamic University of Malaysia. The economics literacy level was 12 points or 60 % which was still considered low. It can be concluded that the mastery of economics literacy is low among foundation programme and higher institution students. This low literacy could be explained due to the lack of exposure given to students to read or discuss the economic issues. Students might not be encouraged to participate in economic dialogues or forums that discuss how the economy can give impact to their lives eventhough they are not taking the economy course.

D. Mastery Level of Inventive Thinking

Table 5 displays the mastery level of inventive thinking. It reveals that the mastery level of inventive thinking was high (mean = 3.98, sd = 0.69) amongst science foundation programme students.

TABLE V
MEAN AND SD OF INVENTIVE THINKING

Subdomain	Mean	sd	Level
Regulatory	4.30	0.49	High
Curiosity	4.14	0.52	High
Risk taking	3.94	0.50	High
Higher order thinking	3.97	0.51	High
Flexibility	3.71	0.54	High
Creativity	3.53	0.39	Moderate
High productivity	3.96	0.69	High

All subdomains of inventive thinking were at a high level except for creativity that showed a moderate level. Regulatory has the highest score (mean = 4.30, sd = 0.49) while creativity has the lowest level (mean = 3.53, sd = 0.39). Students demonstrated a moderate level of mastery in creativity. Creativity in this context means students' ability to use imagination in developing new and original products [5]. Among the items asked in the subdomain of creativity are " I always produce a new idea in my science class" and "I do not produce a new product from my science knowledge."

This finding is in line with the study carried out that revealed the lack of critical and creative thinking among postgraduate students [7]. This may due to the current

education system in Malaysia is predominantly teacher centered and examination oriented [16], [17]. Little time has been spent on discussing the scientific ideas and interpreting the findings during the practical science class. Besides that, the teaching approach used is mainly less inquiry-based and didactic. Thus, this teaching approach may not be able to encourage students to think creatively until they can create science products or innovative products.

E. Mastery Level of Effective Communication

The mastery level of effective communication was high (mean = 3.94, sd = 0.35). All subdomains were at a high level except for interactive communication was at a moderate level. The subdomains and their means of effective communication are reported in Table 6.

TABLE VI
MEAN AND SD OF EFFECTIVE COMMUNICATION

Subdomain	Mean	sd	Level
Cooperative	4.22	0.47	High
Interpersonal	3.91	0.47	High
Responsibility	3.83	0.49	High
Interactive communication	3.57	0.59	Moderate
21st century skills	4.03	0.32	High

Cooperative showed the highest score (mean = 4.22, sd = 0.47) while interactive communication showed the lowest score (mean = 3.57, sd = 0.59). Students' mastery in interactive communication was moderate. Interactive communication refers to the ability to express, deliver, transfer, access and understand information [5]. Among the items for interactive communication are "I rarely discuss any problems or issues in science with colleagues using current technology" and "I know how to use ICT to share or discuss ideas with friends." Students use the internet more on socializing and entertainment rather than academic purposes [18], [19]. [20] also reported that there was a low correlation between hours spent on the internet for academic purposes among Malaysian higher education institution students. Therefore, the students still do not fully utilize the internet to discuss ideas, problems or issues in subject matters with their colleagues.

F. Mastery Level of High Productivity

The mastery level of high productivity in using technology is demonstrated in Table 7. All subdomains of high productivity were at a high level (mean = 3.96, sd = 0.69). This gave an implication that the mastery level of high productivity in using technology was high amongst science foundation programme students. Use of technology showed the highest mastery level (mean = 4.30, sd = 0.56) and quality production showed the lowest (mean = 3.85, sd = 0.59). Among the items asked in quality production subdomain are " I am confident that my product is original", "I use a variety of media (text, audio, video) and other technology to add value to my product" and "I identify the benefits of using my product so that it can solve the existing problems". Nonetheless, all these subdomains of high productivity in using technology were high.

TABLE VII
MEAN AND SD FOR HIGH PRODUCTIVITY

Subconstruct	Mean	sd	Level
Use of technology	4.30	0.56	High
Prioritizing in planning	4.01	0.49	High
Quality production	3.85	0.59	High
High productivity	3.96	0.69	High

G. Effects of Former School Location and Gender on the 21st Century Skills

Table 8 shows an analysis of a two-way ANOVA for the effect of former school location and gender on the 21st-century skills. The significant degrees for former school location, gender, and interaction of former school location and gender were more than 0.05 ($p < 0.05$). These implied that there were no significant differences between former school location and gender on the mastery of the 21st-century skills.

TABLE VIII
TWO-WAY ANOVA FOR FORMER SCHOOL LOCATION AND GENDER

Main effect	Total square	df	Mean square	F value	Degree of Significant (p<0.05)
Location	0.002	1	0.002	0.017	0.896
Gender	0.021	1	0.021	0.208	0.649
Location* gender	0.130	1	0.195	1.933	0.166
Error	23.75	236	0.101		
Total	3925.940	250			

Also, there was no interaction between former school location and gender on the mastery of the 21st century skills as shown in Fig. 2. These findings are inconsistent with [9] that revealed a significant difference in the mastery of the 21st-century skills based on gender. Former school location and gender gave no effect on the mastery of the 21st-century skills amongst science foundation programme students. This may result from the prior selection made by MARA during their enrollment in these colleges. They were among the high achievers in the country regardless of gender or former school location they underwent for their secondary education.
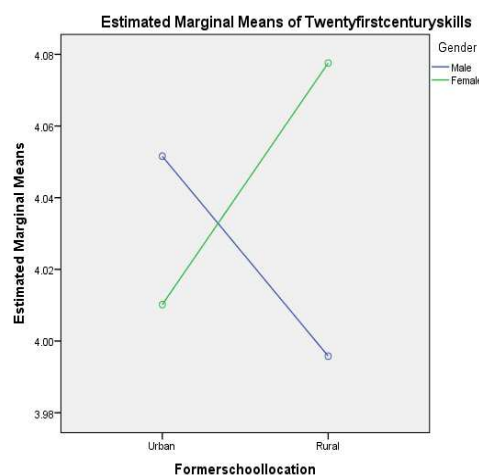

Fig. 2 Interaction effect between former school and gender for the 21st-century skills

H. Effects of Former School Location and Gender on Digital Era Literacy

Table 9 indicates an analysis of two-way for former school location and gender on digital age literacy. The significant degrees for former school location, gender, and interaction of former school location and gender were greater than 0.05 ($p<0.05$).

Main effect	Total square	df	Mean square	F value	Degree of significant ($p<0.05$)
Location	3.004E-7	1	3.004	0.024	0.999
Gender	0.003	1	0.003	0.024	0.878
Location* gender	0.247	1	0.088	0.908	0.432
Error	33.668	236	0.101		
Total	3921.903	240			

There were no significant differences in the level of digital era literacy based on former school location and gender. This brought an implication that there were no effects of former school location and gender on digital age literacy. Besides, there was also no interaction between former school location and gender as shown in Fig. 3.
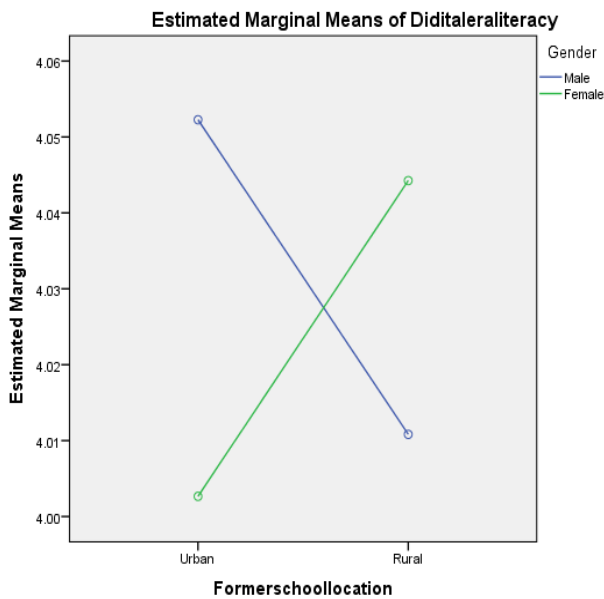

Fig. 3 The interaction effect between former school and gender for digital era literacy

I. Effects of Former School Location on Inventive Thinking

A two-way ANOVA analysis demonstrates in Table 10 that the significant degrees for gender, location and interaction of gender and previous school location were more significant than 0.05 ($p<0.05$).

Main effect	Total square	df	Mean square	F value	Degree of Significant ($p<0.05$)
Location	0.010	1	0.010	0.006	0.938
Gender	0.007	1	0.007	0.048	0.826
Location* gender	0.305	1	0.305	2.042	0.154
Error	35.240	236	0.149		
Total	3574.148	240			

There were no significant differences in the level of inventive thinking based on former school location and gender. Concerning the effect of gender, this finding affirms the study conducted that also revealed no significant difference in inventive thinking among undergraduates students [21. Also, there was no interaction between former school location and gender on the mastery level of inventive thinking as illustrated in Fig. 4. As a consequence, former school location and gender caused no effects on the mastery level of inventive thinking.
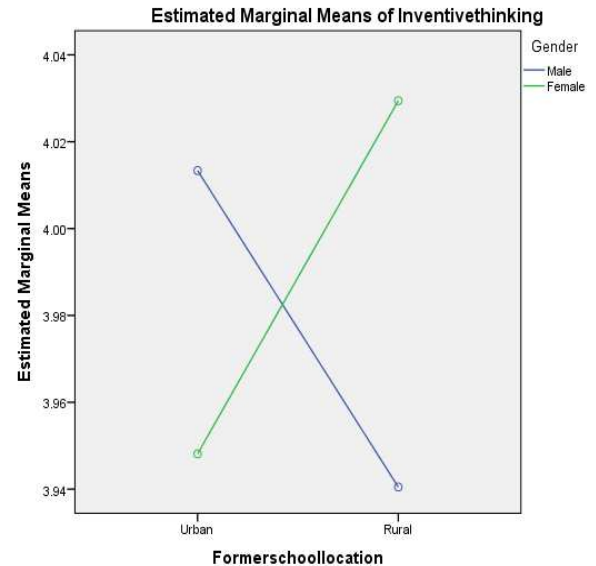

Fig. 4 Interaction effect between former school and gender for inventive thinking

J. Effects of Former School Location and Gender on Effective Communication

Table 11 reports an analysis of a two-way ANOVA for former school location, gender, and interaction between former school location and gender on effective communication. From the table, the significant degrees for former school location, gender, and interaction between former school location and gender were greater than 0.05 ($p<0.05$). As a result, former school location and gender gave no effect on the mastery level of effective communication.

TABLE XI
TWO-WAY ANOVA FOR FORMER SCHOOL LOCATION AND GENDER

Main effect	Total square	df	Mean square	F value	Degree of significant (p<0.05)
Location	0.015	1	0.015	0.125	0.724
Gender	0.076	1	0.076	0.626	0.429
Location* gender	0.137	1	0.137	1.131	0.289
Error	28.581	236	0.121		
Total	3754.148	240			

Meanwhile, there was no interaction between former school location and gender as illustrated in Fig. 5.
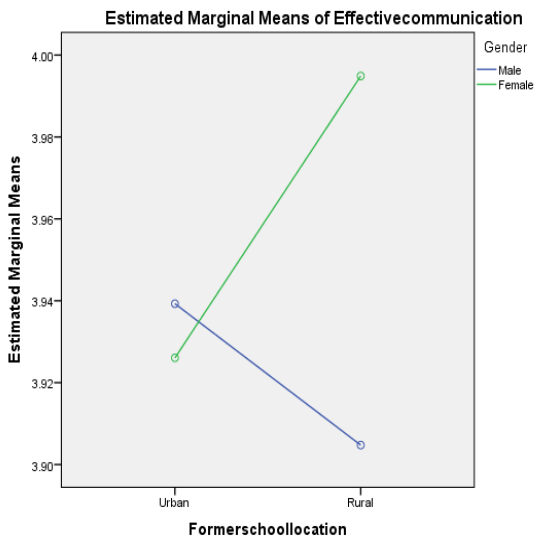

Fig. 5 Interaction effect between former school and gender for effective communication

K. Effects of Former School Location and Gender on High Productivity

An analysis of a two-way ANOVA for former school location, gender, and interaction between former school location and gender on high productivity is reported in Table 12. From the table, the significant degrees for former school location and gender were more significant than 0.05 ($p < 0.05$). Due to that, no significant differences in the mastery level of high productivity based on former school location and gender.

TABLE XII
TWO-WAY ANOVA FOR FORMER SCHOOL LOCATION AND GENDER

Main effect	Total square	df	Mean square	F value	Degree of Significant (p<0.05)
Location	0.008	1	0.008	0.036	0.849
Gender	0.103	1	0.103	0.472	0.493
Location* gender	1.369	1	1.369	6.291	0.013*
Error	51.355	236	0.218		
Total	3820.022	240			

However, the significant degree for interaction between former school location and gender was less than 0.05 (as highlighted in Table 14). Consequently, there was a significant interaction between former school location and gender on the mastery level of high productivity as demonstrated in Fig. 6. This implied that urban male students showed higher productivity compared to rural male students but vice versa for female students. Rural female students showed higher productivity compared to urban female students. This may occur due to motivational domains such as self-efficacy, interest, and enjoyment in using technology that these rural female students showed a higher mastery level of high productivity [22].
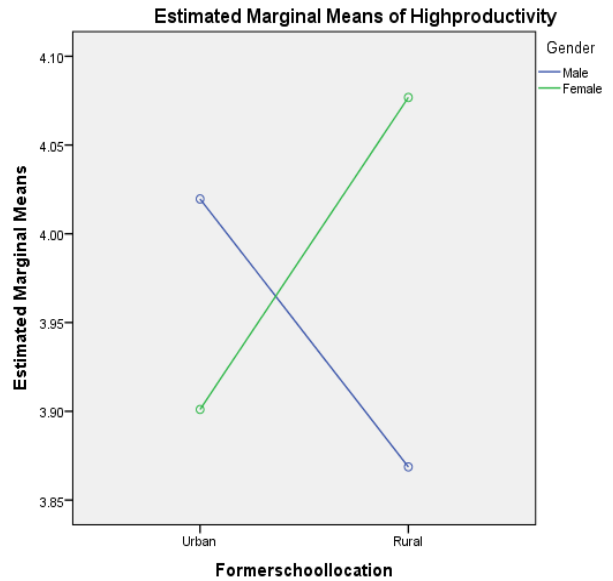

Fig. 6 Interaction effect between former school and gender for high productivity

IV. CONCLUSION

The findings have demonstrated that the mastery level of the 21st-century skills was high amongst the science foundation programme students. All of the subdomains which are digital era literacy, inventive thinking. Effective communication and high productivity also revealed a high mastery level. However, economic literacy as one of the subdomains in digital era literacy showed a moderate level of mastery. Meanwhile, creativity as one of the subdomains in inventive thinking also demonstrated a moderate level of mastery. For active communication subdomains, interactive communication also showed a moderate level of mastery.

About the effects of former school location and gender, it can be concluded that there were no significant differences in the mastery level of the 21st-century skills. This gave an implication that either the students were from urban or rural school previously, they still possessed high mastery level of the 21st-century skills and all the subdomains investigated. Only high productivity in using technology indicated an interaction between former school location and gender. Urban male students acquired higher mastery of high productivity compared to rural male students. Contrary, rural female students acquired higher mastery of productivity compared to the urban female student.

In light of these findings, the researchers would like to propose some suggestions to enhance the 21st-century skills amongst the students. The 21st-century skills should be integrated into the curriculum, and its implementation should be given attention. This is a more organized and faster way to enhance the mastery of the 21st-century skills. Curriculum developers should realize the importance of the new set of workforce skills that meet the demand of the employers and thus, the education system should prepare the students with these necessary skills. The 21st-century curriculum should pay attention to students' knowledge construction and promote students to generate the information that is meaningful for them in developing new skills and literacies [23].

Besides curriculum, a new pedagogical approach that is tailored to the teaching and learning in the 21st century should be implemented. As we go much deeper into the digital era, it is suggested that the new pedagogy will utilize educational technology which can support the student in the transmission of information [24]. For digital age literacy, students should be encouraged to read, interpret, analyze, and evaluate the information from the digital sources. Then, they organize, integrate and synthesize new information that contributes to the knowledge. By using the internet, students can expand their knowledge on current issues and instill social values in multiple areas such as economic, food deficiency, global warming, poverty, issues of health, overpopulation and other social issues [23].

For inventive thinking, teachers can use problem-based solving approach to increase creative and critical thinking. In this approach, students will discuss, disintegrate, analyze, and relate the problems with the real world. Then, they will offer explanations, considerations, judgments and appropriate suggestions on how to solve the assigned problems. Through this approach, students will enhance their curiosity, creative and critical thinking, risk-taking and flexibility. As the world is getting more complex, students should be prepared to solve nonroutine and complex problems they would face in the future workplace and social life.

For effective communication, teachers are encouraged to use cooperative learning or collaborative learning. In cooperative learning, students are divided into groups with different abilities and interests. They will discuss in the group and produce a better and more creative work since everyone has his/her ability and strength compared to work alone [23]. Through this approach, the students will enhance their effective communication subdomains which are cooperative, interpersonal, responsibility and interactive communication. In collaborative learning, students with a broad spectrum of capabilities and aptitudes would share their knowledge and create an understanding among them [25]. Through this pedagogy, the students can enhance their communication and interaction such as to question, explain, justify opinions, articulate and elaborate. Students' effective communication can be fostered through this cooperative learning and collaborative learning.

For high productivity, production skills emphasize the creation of new contents. Students with ICT production skills could start a blog, generate a spreadsheet, design a website or make a video using suitable software [26].

College and university curricula should encourage students to engage in some form of digital exploration and research such as specific courses, collaborative group projects and problem-solving activities [27]. Through these activities, students can develop their digital skills since they have to utilize technology to gather and share information.

Other than that, teachers can assign project-based learning to students to enhance high productivity and quality production among science students. Students can work on individual or group projects on the assigned science topic. Students may use the internet, a learning management system (LMS), hand-held devices such as probeware and smartphone, digital camera and other technology devices. Students can express their ideas in creative ways using multimedia and authoring tools such as iMovies, WebQuest, keynote presentation, montage and a range of iPad Apps [28]. Students can also create serious games. Serious games are digital applications which contain a set of designed tasks that reflect cognitive functions such as reasoning, problem-solving, decision making and acting in a particular context [29]. Through this project-based, the student will plan, prioritize and manage their project to meet the deadline. Furthermore, they use effective real-world tool to aid the execution of the project and eventually produce relevant, high quality and authentic product.

For future work, this study can be extended to other foundation colleges such as matriculation colleges since they have a bigger population of students that aged 18-19 years. Besides matriculation colleges that fully funded by the government, this study can also be carried out among students of the same age who further their studies at self-funded foundation colleges.

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